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I.—*On a Simple Method of using an insignificant Fraction of the Main Current produced by a Dynamo-Electric Machine for Telegraph Purposes.*—*By* Louis Schwendler, M. Inst. C. E. &c.

(Received 29th October ; read November 5th, 1879.)

The currents which a dynamo-electric machine is able to generate through a small external resistance, are so enormously strong and also so constant and exceedingly cheap, that I have always thought it would be of technical as well as of economical importance to use them for signalling purposes. The difficulty only was how to solve the problem practically. Manifestly, the currents could not be produced through the telegraph lines, in the ordinary manner of applying dynamo-electric machines, for, in the first place, telegraph lines offer high resistance, and, in the second place, the use of *the closed-circuit system* would become imperative. However, some time ago a very simple method occurred to me which appears to contain the germs of practical success, and, having lately made some experiments on the subject, I do not hesitate to communicate the result.

Suppose we have a dynamo-electric machine, the two terminals of which are connected by a resistance r through which any kind of *useful work* is to be performed by the current.

For instance, during the night, r may consist of an electric arc, and the useful work done by the current is given out as *light* for the *signalling office ;* or during the day-time r may consist of another dynamo-electric machine which acts as an ordinary electromagnetic engine, performing some useful mechanical work, *i. e.*, pulling the punkhas, lifting messages, producing a draught of cool air, &c. ; or the current may be made to pass through a galvanoplastic apparatus in connection perhaps with the Surveyor General's Office, &c.

Now connecting the *negative pole** of such a dynamo-electric machine to earth, the positive pole to *all* the lines terminating in a telegraph office, while the two poles are permanently connected by the resistance r through which the current produces the useful work above-mentioned, then it will be clear, without demonstration, that *all* the lines so connected can be provided with signalling currents (which are exceedingly weak as compared with the strong main current) by simply *tapping* the main current, and that without perceptibly reducing it, *i. e.*, without affecting the *useful work* performed by the main current through r. Supposing that the useful work performed by the main current repays all the expenses connected with the erection and working of the dynamo-electric machine, then obviously this would be a method which would supply the signalling currents for nothing. This might be an inducement for telegraph-administrations to introduce the electric light, since they would get the signalling currents into the bargain, and the costly and cumbersome galvanic apparatus might be dispensed with.

An example will show this more clearly. A Siemens dynamo-electric machine of medium size can easily be made to produce through an electric arc a current of 30,000 milli-oerstedts, of which not more than 3 milli-oerstedts are required to work the Siemens's polarized relay with engineering safety. Suppose that the sent current is made equal to twice the current which is required to arrive, we have the following calculation for Calcutta office :—14 long lines terminate at Calcutta, hence $14 \times 6 = 84$ milli-oerstedts would (as a maximum) have to be tapped off from the main current of 30,000 milli-oerstedts. This represents a loss of only 0·28°/₀,—which is so small that not even the most sensitive eye would be able to detect any variation in the light.

Hence in this case we would feed the Telegraph lines with currents which actually cost nothing, as the electric light alone would repay all expenses.

During my recent light experiments in London, it was experimentally established that the current in milli-oerstedts which a dynamo-electric machine is able to produce, can be expressed as follows :—

$$C = E \left\{ \frac{1 - e^{-K\left(\frac{r}{r+m}\right)^2}}{r + m} \right\} \times 1000$$

* In India we use positive signalling currents.

E and K are two *constants* for any dynamo-electric machine. E is an electromotive force in volts; K is of such dimensions that $v\sqrt{K}$ represents an electrical resistance; m is the internal resistance of the dynamo-electric machine; r is the external resistance through which the useful work by the main current has to be performed.

m and r are to be expressed in ohms. The resistance of the leading wires has been supposed *nil.*

If we call R the resistance of a telegraph line, which we wish to feed from the main current, then the signalling current passing into that line when the main current is tapped would be

$$\frac{C\,r}{R + r} = E \left\{ \frac{1 - e^{-K\left(\frac{v}{r + m}\right)^2}}{r + m} \right\} \times \frac{1000\,r}{R + r}$$

and this current, in the case of the Indian lines, should not be less than 6 milli-oerstedts. Hence we have the following equation:—

$$E \left\{ \frac{1 - e^{-K\left(\frac{v}{r + m}\right)^2}}{r + m} \right\} \times \frac{1000\,r}{R + r} = 6$$

from which r can be calculated, since E, K, m, v and R are known.

I need scarcely point out, that as R is invariably so large that r can be neglected in comparison with it; the current in *one* line only depends on the resistance of that line, and not on the resistance of the other lines in connection with the dynamo-electric machine. Hence the signalling through one line is not influenced by the signalling on other lines; and in this respect the method is on a par with signalling through different lines by separate batteries.

We will take a special case.—For a Siemens's medium machine, making $r = 3$, we have a main current of about 17,710 milli-oerstedts, and the current passing into a line of 8000 resistance (800 miles of $5\frac{1}{2}$ wire) would be 6·6 milli-oerstedts. Supposing that all the 14 lines at Calcutta office are to be supplied with 6·6 milli-oerstedts each, the current carried off would be $6{\cdot}6 \times 14 = 92{\cdot}4$ milli-oerstedts, or 0·5 °/₀ of the main current.

It is best to make all the lines equal in resistance by adding to the shorter lines some artificial resistance. This measure would prevent a dead earth (occurring on one of the lines and close to Calcutta) from having any effect on the working of the other lines. In Europe, where the lines are much shorter, the signalling currents supplied by a given dynamo-electric machine, working through a given resistance r, could be much greater than 6·6 milli-oerstedts.

For any given R (resistance of the line) the currents can be increased by selecting a dynamo-electric machine with the right internal resistance.

The advantages of the method appeared to me sufficiently great to justify a practical trial :—

Experiment, October 11, 1879. With a Siemens's dynamo-electric machine (medium size) I produced a powerful electric light ; and between the poles of the dynamo-electric machine I connected up four artificial lines, each of 10,000 units resistance, with relays ranging between 500 to 1000 units. These four parallel circuits worked very well, singly and simultaneously. No variation of the electric light during telegraphing could be noticed, even when the line resistance was reduced to 1000 units. Further, the resistance of one line was increased to 20,000, and the signalling currents were still sufficiently strong (1·6 milli-oerstedts).

Experiment, October 14, 1879. Same as above ; but a branch current was conveyed by the store-yard line (from the store-yard where the dynamo-electric machine with its electric light was put up) to Calcutta signalling-office (4 miles), and one of the Agra lines (850 miles in length) worked by this current.

The sent current, measured at Calcutta, was 9·6 milli-oerstedts ; the received current, measured at Agra, 1·85. The great loss was due to the exceedingly low insulation of the line near Calcutta. It is now the breaking up of the monsoons, when the climate in lower Bengal represents almost a hot vapour bath.

Several messages were sent to Agra, but no variation in the electric light could be observed.

II.—*On the Occurrence of the Musk-Deer in Tibet.*

By R. Lydekker, B. A.

(Received November 17th, 1879.)

Some degree of doubt seems, hitherto, to have prevailed among naturalists whether the Musk-Deer *(Moschus)* occurs on the Tibetan plateau, or whether it is confined to the wooded districts of the Alpine Himalaya. Thus in a paper contributed by Mr. W. T. Blanford to the 'Proceedings of the Zoological Society of London,'* the author says that he has grave doubts whether the Musk-Deer occurs anywhere on the Tibetan plateau. In a paper published by myself in the Society's Journal,† I mentioned that, from having seen skins in Ladák, as well as from the fact of the Ladákis

* 1867, p. 634. † 1877, Pt. II, pp. 287-8.